Image AF/2872

Docket No.: YHK-0039

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF APPEALS AND INTERFERENCES

In re Application of	:	
Ho Young CHOI et al.	:	
Serial No.: 09/514,250	:	Group Art Unit: 2872
Confirm. No.: 9403	:	Examiner: Audrey Chang
Filed: February 28, 2000	:	Customer No.: 34610
For: PROJECTION LENS SYSTEM	:	

RESUBMISSION OF APPEAL BRIEF IN REPLY TO NOTIFICATION OF NON-COMPLIANCE WITH 37 CFR 1.192(c)

U.S. Patent and Trademark Office
2011 South Clark Place
Customer Window,
Crystal Plaza Two, Lobby, Room 1B03
Arlington, Virginia 22202

Sirs

In response to the Notification of Non-Compliance with 37 CFR 1.192(c) dated March 16, 2004, attached is the corrected Appeal Brief in triplicate.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this, concurrent and future replies, including extension of time fees, to Deposit Account 16-0607 and please credit any excess fees to such deposit account.

Respectfully submitted,
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APPEAL BRIEF

U.S. Patent and Trademark Office
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Crystal Plaza Two, Lobby, Room 1B03
Arlington, Virginia 22202

Sir:

This Appeal Brief is submitted in support of the Notice of Appeal filed October 15, 2003.

REAL PARTY IN INTEREST

The party in interest is the assignee, LG Electronics Inc. The assignment document is recorded at Reel 010644 and Frame 0451.

RELATED APPEALS AND INTERFERENCES

There are no related appeals and interferences.

STATUS OF THE CLAIMS

This is an appeal from a fifth Office Action Final Rejection dated July 15, 2003 of claims 19-25 and 61-82. No other claims are pending.

STATUS OF AMENDMENTS

All Amendments filed in this application have been entered. A correct copy of appealed claims 19-25 and 61-82 including all entered amendments thereto, appears in the attached Appendix A.

SUMMARY OF THE INVENTION

The invention relates to a projection lens system that includes four lenses. The claimed system includes four specific lenses in combination with a particularly placed diffractive optical element, which provide a projection system which is thinner than related art systems and still provides chromatic aberration correction as well as positive refractive power. The four lens system will be described in conjunction with Fig. 6 of the present application.

In the projection lens system embodying the invention, a first aspheric plastic lens 20 is provided with a positive refraction in the center and negative refraction in the peripheral regions. This first aspheric lens 20 corrects spherical aberrations, coma aberrations and astigmatisms. A second glass lens 22 is provided next to the first lens 20 and is made of glass and includes a positive refractive power providing a majority of the refracted power of the system. An aspheric

plastic third lens 24 is located adjacent the second lens 22 and includes a diffractive optical element (DOE) 24A which forces the focusing distance of red wavelength light to be a shorter focusing distance than blue wavelength light and also provides some positive refractive power. This third lens 24 also provides for correction of astigmatisms and field curvature distortion. Finally, an aspheric plastic fourth lens 26 is provided which has a negative refractive power and also corrects for astigmatisms and field curvature. This specific, novel four lens system in combination with refractive lens 28 provides for proper chromatic dispersion characteristics and a thinner overall system width in a projection lens system. See also Figs. 7a and 7b.

Claims 19, 67 and 74 are the only independent claims and read as follows:

19. A projection lens system, comprising:

a first lens having a positive refractive power at the center thereof and a negative refractive power at the peripheral thereof;

a second lens having a relatively large positive refractive power;

a third lens having a positive refractive power;

a fourth lens having a negative refractive power; and

a diffractive optical element formed on at least one surface of said lenses.

67. A projection lens system, comprising:

a first lens having a positive refractive power at the center thereof and a negative refractive power at the peripheral thereof;

a second lens having a relatively large positive refractive power;

a third lens having a positive refractive power;

a fourth lens having a negative refractive power; and

a diffractive optical element formed on at least one surface of said lenses, wherein the shape of the first lens and the shapes of the third and fourth lenses are defined by the following equation:

$$X(r) = (cr^2/(1+(1-(1+K)c^2 r^2))^{1/2}) + Ar^4 + Br^6 + Cr^8 + Dr^{10} + Er^{12},$$

wherein X(r) is a sag value with reference to an aspheric surface at a height r from an optical axis, c defines a curvature of a lens surface at the height r from an optical axis, K is a conic constant, and A to E define aspheric coefficients.

74. A projection lens system, comprising:

a first lens having a positive refractive power at the center thereof and a negative refractive power at the peripheral thereof;

a second lens having a relatively large positive refractive power;

a third lens having a positive refractive power;

a fourth lens having a negative refractive power; and

a diffractive optical element formed on at least one surface of said lenses, wherein the fourth lens and the diffractive optical element have chromatic dispersion characteristics opposite to one another.

ISSUES

1. Whether, under 35 U.S.C. § 112, first paragraph, claims 63, 69 and 75 fail to comply with the written description requirement.

2. Whether, under 35 U.S.C. § 103(a), the Examiner has established a *prima facie* case of obviousness that claims 19-25, 61-63, 65-69, 71-75 and 77-82 would have been obvious to one of ordinary skill in the art at the time the invention was made over Moskovich (U.S. Patent No. 4,776,681) in view of Ogata et al. (U.S. Patent No. 5,982,544, hereinafter Ogata).

3. Whether, under 35 U.S.C. § 103(a), the Examiner has established a *prima facie* case of obviousness that claims 64, 70 and 76 would have been obvious to one of ordinary skill in the art at the time the invention was made over Moskovich and Ogata in further view of Maruyama et al. (U.S. Patent No. 5,838,496, hereinafter Maruyama).

GROUPING OF THE CLAIMS

Appealed claims 20-25, 65, 71, 77 and 79 form a single group and stand or fall together with claim 19.

Appealed claims 61 and 78 form a single group and stand or fall together with appealed claim 67.

Appealed claims 63-64, 68-70 and 74-76 form a single group and stand or fall together with appealed claim 62.

Appealed claims 72 and 80 form a single group and stand or fall together with appealed claim 66.

Appealed claim 81 forms a single group and stands or falls together with appealed claim 73.

LEGAL STANDARD

The initial burden of establishing a basis for denying patentability to a claimed invention rests upon the examiner. In re Fine, 837 F.2d 1071, 5 USPQ 2d 1596 (Fed. Cir. 1988); In re Thorpe, 777 F.2d 695, 227 USPQ 964 (Fed. Cir. 1985); In re Piasecki, 745 F.2d 1468, 223 USPQ 785 (Fed. Cir. 1984). In rejecting claims under 35 U.S.C. 103, it is incumbent upon the examiner to establish a factual basis to support the legal conclusion of obviousness. Stratoflex, Inc. v. Aeroquip Corp., 713 F.2d 1530, 218 USPQ 871 (Fed. Cir. 1983); In re Warner, 379 F.2d 1011, 154 USPQ 173 (CCPA 1967). In so doing, the examiner is required to make the factual determinations set forth in Graham v. John Deere Co. of Kansas City, 383 U.S. 1, 148 USPQ 459 (1966), **and** to provide a reason why one having ordinary skill in the art would have been led to modify the prior art or to combine prior art references to arrive at the claimed invention. Ashland Oil, Inc. v. Delta Resins & Refractories, Inc., 776 F.2d 281, 227 USPQ 657 (Fed. Cir. 1985). Such a reason must stem from some teaching, suggestion or inference in the prior art as a whole or knowledge generally available to one having ordinary skill in the art. Uniroyal, Inc. v.

Rudkin-Wiley, 837 F.2d 1044, 5 USPQ2d 1434 (Fed. Cir. 1988); Ashland Oil, Inc. v. Delta Resins & Refractories, Inc., 776 F.2d 281, 227 USPQ 657 (Fed. Cir. 1985); ACS Hospital Systems, Inc. v. Montefiore Hospital, 732 F.2d 1572, 221 USPQ 929 (Fed. Cir. 1984); In re Sernaker, 702 F.2d 989, 217 USPQ 1 (Fed. Cir. 1983).

In determining obviousness, the inquiry is not whether each element existed in the prior art, but whether the prior art made obvious the invention as a whole for which patentability is claimed. Hartness Int'l, Inc. v. Simplimatic Eng'g Co., 819 F.2d 1100, 2 USPQ2d 1826 (Fed. Cir. 1987). It is impermissible to pick and choose from any one reference only so much of it as will support a given position, to the exclusion of other parts necessary to the full appreciation of what such reference fairly suggests to one of ordinary skill in the art. In re Wesslau, 353 F.2d 238, 147 USPQ 391 (CCPA 1951). Piecemeal reconstruction of prior art patents is improper, In re Kamm, 452 F.2d 1052, 172 USPQ 298 (CCPA 1972). The Examiner has not met the burden of proof in establishing the obviousness of the appealed claims, particularly to the extent that the claims require a complete four lens system similar to Moskovich in addition to only one single part of Ogata's six lens system, a diffractive optical element.

THE REFERENCES CITED

A. The Moskovich Reference

In Moskovich, a four lens system is disclosed, but the system includes, as illustrated in Moskovich Figure 3, a positive refractive power first lens L1, a weak positive to weak negative second lens L2, a corrector lens unit L3 and a negative lens L4, where the system does not disclose or suggest the use of any diffractive optical elements. Moskovich's four lens system includes one equation delineating a relationship between each lens in the system for correcting aberrations and providing a complete projection lens system.

B. The Ogata Reference

Ogata discloses a compact yet high-zoom-ratio zoom lens system for use with lens shutter cameras, see Ogata Abstract. In example 4, which is illustrated in Fig. 7 in Ogata, a sixth lens system is illustrated where multiple lenses include diffractive surfaces. Each of the lenses is specifically chosen, as are the specific diffractive surfaces on specific lenses to achieve a camera zoom lens system satisfying certain criteria.

C. The Maruyama et al. Reference

The Maruyama et al. reference discloses a diffractive multi-focal objective lens formed as a double convex lens having convex aspherical surfaces of which radii of curvatures are larger as a function of distance from an optical axis. See Maruyama et al. Abstract.

THE ARGUMENT

A. 35 U.S.C. § 112, First Paragraph

The Office Action states that claims 63, 69 and 75 recite features not supported by the original disclosure and are rejected under 35 U.S.C. § 112, first paragraph for failing to comply with the written description requirement. See Office Action dated July 15, 2003, pages 2-3, items 1 and 3. The Office Action is incorrect in this assertion.

As discussed in the original specification "the third lens 24 including a plastic lens (i.e., a refractive lens) have a positive refractive power and the diffractive optical element 24A . . . the third lens 24 forces the chromatic aberrations for the red, green and blue to decrease, thereby enhancing the chromatic aberration correction characteristic." See page 16, lines 2-20 (emphasis added). Thus, by definition in the original specification, the third lens of the claimed invention includes a plastic lens and a diffractive optical element (DOE).

As such, the third lens, which includes a DOE, clearly has been specified to force chromatic aberrations to decrease thereby enhancing the chromatic aberration correction characteristic, therefore written description is provided for each of these claims. Applicants submit that a DOE is included on a third lens therefore written description is adequately provided. For at least this reason, it is respectfully submitted that the rejection of claims 63, 69 and 75 under 35 U.S.C. § 112, first paragraph is improper and should be withdrawn.

B. 35 U.S.C. 103(a)

The Office Action finally rejects claims 19-25, 51-63, 65-69, 71-75 and 77-82 under 35 U.S.C. § 103(a) over Moskovich in view of Ogata. The Office Action also finally rejects claims 64, 70 and 76 under 35 U.S.C. § 103(a) over Moskovich, Ogata and Maruyama. Because the references do not render the features of the claimed invention obvious, Applicants submit that the rejections are improper and should be withdrawn. Each of the groups of claims which stand or fall together will now be discussed.

1. Independent Claim 19

Applicants respectfully submit that the rejection under 35 U.S.C. § 103(a) fails to meet the *prima facie* case of obviousness because Moskovich and Ogata fail to disclose, suggest or make obvious the recited features of claim 19. Applicants further submit that one of ordinary skill in the art would not be motivated to modify Moskovich's invention to include a diffractive optical element because Moskovich's system addresses and corrects aberrations without any need for additional parts and any additions to the system would either be redundant or could destroy or hurt Moskovich's system. Additionally, the Office Action does not provide any other motivation (besides correcting aberrations) for combining the Moskovich and Ogata references.

Applicants submit that while Moskovich discloses a four lens system generally, Moskovich in and of itself provides a complete, aberration corrected projection lens system. Inclusion of a diffractive optical element from Ogata would not have been obvious because

Moskovich's system has proper chromatic and aberration corrections through use of its individual specifically selected group of lenses, which are each chosen for the exact purpose of chromatic and aberration corrections. Thus, the addition of the diffractive optical element of Ogata, which incidentally is required specifically for the specific lens system of Ogata, is not only unnecessary, but could also introduce new errors into Moskovich's system thus hurting or destroying the system.

The Moskovich lens system does not have any problems with aberrations as the lens system of Moskovich includes a corrector lens unit L3 where if an axial bundle denoted by rays R_A is held to a small height H_A can be utilized to correct aberrations. See Figures 3 and 7, and col. 7, lines 3-11 of Moskovich. Furthermore, as illustrated in Fig. 8 of Moskovich, a corrector lens unit CR can be used to correct residual aberrations. See Moskovich col. 8, line 3-31.

Therefore, since corrector lens units L3 and CR are used, simple addition of a diffractive optical element could introduce new aberrations and simple substitution would require additional consideration to find new lens elements to provide the power of the original corrector lens unit, while also having to work in conjunction with a diffractive optical element. Thus, the addition of a diffractive optical element into the Moskovich system would not be obvious, as such addition or substitution of a diffractive optical element would not provide any additional optical benefits, but rather may create its own problems and aberrations. This is contrary to the Office Action's statement that forming a diffractive optical element on a lens in Moskovich would correct aberrations in a projector lens system as such corrections were already accounted

for by the Moskovich system.

Furthermore, the specific lenses and diffractive elements chosen in the preferred embodiment of the present application were specifically chosen to provide a projection system that could be made thinner than conventional and related art system. Because thinness is desired in the claimed invention, only four lenses and a diffractive optical element are used in the claimed invention rather than the six lenses required in Ogata for a camera or the four lenses in Moskovich, which did not use or contemplate using a diffractive optical element. Each lens of the claimed invention was specifically chosen in combination with the other specific lenses and the diffractive optical element in order to provide the thinness desired in the claimed projection lens system.

Thus, Applicants respectfully submit that Moskovich and Ogata, individually or in combination, do not teach or suggest the four lens system as claimed, which includes a diffractive optical element, as recited in claim 19. For at least this reason, it is respectfully submitted that the rejection of claim 19, under 35 U.S.C. § 103(a) is improper and should be withdrawn.

2. Independent Claim 67

With respect to claim 67, Applicants respectfully submit that it would not have been obvious to modify Moskovich and Ogata to include a diffractive optical element wherein shapes of the first, third and fourth lenses are defined by the equation recited in claim 67. Applicants

further submit that one of ordinary skill in the art would either use the lens system from Moskovich without any diffractive optical elements as the equation based lenses make all corrections needed for Moskovich's lens system, or would use the diffractive optical element of Ogata with Ogata's six lens system requiring aberration correction. However, since Moskovich requires equation satisfaction for its four lens system, one of ordinary skill in the art would not use both a diffractive optical element and Moskovich's lens system requiring satisfaction of the equation as such addition would be redundant and may cause problems, as mentioned above, nor would any motivation exist to make such a combination.

The Office Action states that Moskovich teaches the formula as stated in col. 5, lines 30-35, however, this equation includes an aspheric coefficient corresponding to the fourteenth order, which is not included in the claimed invention of claim 67. Thus, a shape of the first, third and fourth lenses of the claimed invention are different from the first lens unit G1 which has at least one aspheric surface defined by the equation of Moskovich col. 5, lines 28-34. Additionally, at least the third and fourth lenses of claim 67 differ in shape from those of Moskovich, as they provide different functions within the claimed four lens system from the Moskovich projection lens system.

Thus, Applicants respectfully submit that Moskovich and Ogata, individually or in combination, do not teach or suggest at least the feature of a first, third and fourth lens defined by the recited equation, as recited in claim 67. For at least this reason, it is respectfully submitted that the rejection of claim 67 under 35 U.S.C. § 103(a) is improper and should be withdrawn.

3. Claim 62

Claims 62-64 correspond to claims 68-70 and 74-76, each of which involves chromatic dispersion characteristics in the claimed projection lens system. Claims 64, 70 and 76 are rejected under 35 U.S.C. § 103(a) over Moskovich, Ogata and Maruyama. However, as claims 64, 70 and 76 stand or fall with claim 62 and since Maruyama does not cure the deficiencies of Moskovich and Ogata with respect to at least claim 62, the 35 U.S.C. § 103(a) rejection of claims 64, 70 and 76 will be addressed with claims 62, 63, 68, 69, 74 and 75.

In claim 62, the projection lens system is defined as including a fourth lens and a diffractive optical element which have chromatic dispersion characteristics opposite to one another. Similarly, in claim 63, the projection lens system uses the third lens to force the chromatic aberrations to decrease thus enhancing the chromatic aberrations correction characteristics of the projection lens system. Finally, in claim 64, the projection lens system is defined as including a fourth lens which enables a focal length of a blue light beam to be shorter than that of a red light beam and a diffractive optical element which forces a focusing distance of the red light beam to be shorter than that of the blue light beam, thus correcting chromatic aberrations. Thus, claims 62-64, 68-70 and 74-76 require a projection lens system with chromatic dispersion characteristics being corrected by either a combination of the fourth lens and a diffractive optical element or by the third lens, which includes a diffractive optical element.

The Office Action states that "the idea of using diffractive optical element to correct chromatic aberration is to have the chromatic dispersions created by the diffractive element and

the lens element, intended to be corrected, being opposite to each other. Such feature is therefore either inherently met by the disclosure of Ogata or an obvious modification to one skilled in the art to make the attracted element particularly correcting the chromatic aberrations of the fourth lens for the benefit of improving the image quality of the CRT." See page 4 of the Office Action dated July 15, 2003, second full paragraph.

However, Ogata does not disclose or suggest using a diffractive optical element in combination with a four lens projection lens system as recited in claim 62. Nor would it be an obvious modification to one skilled in the art to just eliminate two of Ogata's six lenses or to use a diffractive optical element in such a manner with the specified characteristics, as none of the cited references disclose primarily creating any chromatic aberrations using any lens, let alone a fourth lens, then correcting these chromatic aberrations in a diffractive optical element. This combination in the claimed invention was intentionally applied to make a thin, chromatically accurate projection lens system where each lens was specifically chosen and a diffractive optical element was specifically chosen and a diffractive optical element was specifically placed to achieve a predetermined desired result. Therefore, the combination of the lenses and the diffractive optical element is novel and nonobvious to make a thinner projection lens system with proper chromatic dispersion characteristics. Further, although diffractive optical elements are admittedly used to correct certain aberrations, none of the cited references suggests or

intimates that aberrations should intentionally be created for offset with a diffractive optical element, which is used in the claimed invention to decrease the thickness of the projection lens system.

4. Claim 66

With respect to claim 66, Applicants respectfully submit that it would not have been obvious to modify Moskovich and Ogata to have provided a second lens providing a majority of the positive refractive power and a diffractive optical element to correct aberrations caused by the second lens, thus creating a thin projection lens system.

The Office Action asserts that "Moskovich teaches that the second lens has the majority of the refractive power . . . The correction of aberrations therefore is mainly directed to the aberration created by the second lens." See the Office Action dated July 15, 2003, page 5, second paragraph. However, Moskovich does not disclose or suggest the use of a diffractive optical element and therefore provides for correction of any aberrations of the second lens through the remainder of the lenses in the system and not a diffractive optical element. Therefore, Applicants respectfully submit that one of ordinary skill in the art would not look to Ogata to cure the deficiencies of Moskovich as Moskovich corrects any and all aberration problems through the use of the other lenses in the system not through the use of a diffractive optical element. Therefore, a diffractive optical element would be redundant at best and would not be required or even desired to correct any aberrations in Moskovich, and the combination of

Ogata and Moskovich would not disclose the thin projection system as recited in claim 66.

Furthermore, Ogata does not use a diffractive optical element in order to provide a thinner lens system or to correct aberrations created in a lens system similar to Moskovich, but rather implement its own six lens camera zoom system, therefore the specific lens system of the claimed invention is nonobvious and novel. For at least these reasons, it is respectfully submitted that the rejection under 35 U.S.C. § 103(a) is improper and should be withdrawn.

5. Claim 73

With respect to claim 73, Applicants respectfully submit that it would not have been obvious to modify Moskovich and Ogata to have first, third and fourth lenses each designed to have an aspheric surface, wherein the shape of each of the first, third and fourth lenses is designed to work in conjunction with the others of the first, third and fourth lenses to correct aberrations.

The Office Action states that "Moskovich teaches the first, third and fourth lenses are each designed to have an aspheric surface, which implicitly have the function of correcting spherical aberrations. It is either implicitly true or an obvious modification to one skilled in the

art to make these lenses work in conjunction to reduce aberrations for the benefit of improving the property of the lens system and the image quality." See the Office Action dated July 15, 2003, page 5, third full paragraph.

However, Moskovich fails to disclose or suggest incorporating any further correction devices, let alone a diffractive optical element or a diffractive optical element formed on a surface of a lens. Thus, while Moskovich may implicitly disclose using a four lens system for correcting aberrations using a combination of lenses, the use of Moskovich's system would not lead one of ordinary skill in the art to modify the system to include a diffractive optical element, let alone using the first, third and fourth lenses in conjunction with a diffractive optical element to make the claimed invention as the lenses would inherently make such corrections.

Thus, Applicants respectfully submit that Moskovich and Ogata, individually or in combination, do not disclose, suggest or render obvious at least the features of claim 73. For at least this reason, it is respectfully submitted that the rejection of claim 73, under 35 U.S.C. § 103(a) is improper and should be withdrawn.

C. Double Patenting

The Office Action rejected claims 61 and 62 with respect to claims 67 and 74 under Double Patenting. However, as each of these claims has not yet been held allowable, Applicants

submit that such rejection should be provisional upon allowance. As such, Applicants submit that this issue should be resolved after allowance and the rejection should be stayed until after allowance of one or more of these claims.

CONCLUSION

For at least the reasons set forth above, Applicants respectfully submit that claims 19, 67, 62, 66 and 73 define patentable subject matter. Claims 20-25 and 61-66 depend from claim 19, claims 68-72 depend from claim 67 and claims 75-81 depend from claim 74, and are allowable for at least the same reasons, as well as their added features and the combinations thereof. Withdrawal of the rejections under 35 U.S.C. § 103 is respectfully requested. Furthermore, withdrawal of the rejection under 35 U.S.C. § 112, first paragraph, for the reasons discussed above, is respectfully requested.

The Honorable Board is respectfully requested to reverse the rejections set forth in the Office Action dated July 15, 2003, and to pass this application to issuance.

Respectfully submitted,
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APPENDIX A

19. A projection lens system, comprising:

a first lens having a positive refractive power at the center thereof and a negative refractive power at the peripheral thereof;

a second lens having a relatively large positive refractive power;

a third lens having a positive refractive power;

a fourth lens having a negative refractive power; and

a diffractive optical element formed on at least one surface of said lenses.

20. The projection lens system according to claim 19, wherein said first, third and fourth lenses are each designed to have an aspheric surface.

21. The projection lens system according to claim 19, wherein one surface of said first lens is designed to have an aspheric surface and the other surface of said first lens is designed into a surface of the diffractive optical element.

22. The projection lens system according to claim 19, wherein one surface of said third lens is designed to have an aspheric surface and the other surface of said first lens is designed into a surface of the diffractive optical element.

23. The projection lens system according to claim 19, wherein a plurality of recesses with a shape of concentric circles are provided at the diffractive optical element in such a manner to have a rotational symmetry.

24. The projection lens system according to claim 23, wherein pitches of said recesses are decreased in such a manner that a phase amount is reduced as it goes from the center of the

diffractive optical element into the peripheral thereof.

25. The projection lens system according to claim 19, wherein at least one of said lenses is made from a plastic.

61. The projection lens system according to claim 19, wherein the shape of the first lens and the shapes of the third and fourth lenses are defined by the following equation:

$$X(r) = (cr^2/(1+(1-(1+K)c^2 r^2))^{1/2}) + Ar^4 + Br^6 + Cr^8 + Dr^{10} + Er^{12},$$

wherein X(r) is a sag value with reference to an aspheric surface at a height r from an optical axis, c defines a curvature of a lens surface at the height r from an optical axis, K is a conic constant, and A to E define aspheric coefficients.

62. The projection lens system according to claim 19, wherein the fourth lens and the diffractive optical element have chromatic dispersion characteristics opposite to one another.

63. The projection lens system according to claim 19, wherein the third lens forces the chromatic aberrations to decrease thus enhancing the chromatic aberration correction characteristic of the projection lens system.

64. The projection lens system according to claim 19, wherein the fourth lens enables a focal length of a blue light beam to be shorter than that of a red light beam and the diffractive optical element forces a focusing distance of the red light beam to be shorter than that of the blue light beam, thus correcting chromatic aberrations.

65. The projection lens system according to claim 19, wherein the combination of lenses in the projection lens system does not require additional lenses having a negative refractive power to enlarge the dispersion of a beam.

66. The projection lens system according to claim 19, wherein the second lens provides the majority of the positive refractive power and the diffractive optical element corrects aberrations caused by the second lens, thus allowing providing a thin projection system.

67. A projection lens system, comprising:

a first lens having a positive refractive power at the center thereof and a negative refractive power at the peripheral thereof;

a second lens having a relatively large positive refractive power;

a third lens having a positive refractive power;

a fourth lens having a negative refractive power; and

a diffractive optical element formed on at least one surface of said lenses, wherein the shape of the first lens and the shapes of the third and fourth lenses are defined by the following equation:

$$X(r) = (cr^2/(1+(1-(1+K)c^2 r^2))^{1/2}) + Ar^4 + Br^6 + Cr^8 + Dr^{10} + Er^{12},$$

wherein X(r) is a sag value with reference to an aspheric surface at a height r from an optical axis, c defines a curvature of a lens surface at the height r from an optical axis, K is a conic constant, and A to E define aspheric coefficients.

68. The projection lens system according to claim 67, wherein the fourth lens and the diffractive optical element have chromatic dispersion characteristics opposite to one another.

69. The projection lens system according to claim 67, wherein the third lens forces the chromatic aberrations to decrease thus enhancing the chromatic aberration correction characteristic of the projection lens system.

70. The projection lens system according to claim 67, wherein the fourth lens enables a focal length of a blue light beam to be shorter than that of a red light beam and the diffractive optical element forces a focusing distance of the red light beam to be shorter than that of the blue light beam, thus correcting chromatic aberrations.

71. The projection lens system according to claim 67, wherein the combination of lenses in the projection lens system does not require additional lenses having a negative refractive power to enlarge the dispersion of a beam.

72. The projection lens system according to claim 67, wherein the second lens provides the majority of the positive refractive power and the diffractive optical element corrects aberrations caused by the second lens, thus allowing providing a thin projection system.

73. The projection lens system according to claim 67, wherein said first, third and fourth lenses are each designed to have an aspheric surface, wherein the shape of each of the first, third and fourth lenses is designed to work in conjunction with the others of the first, third and fourth lenses to correct aberrations.

74. A projection lens system, comprising:

a first lens having a positive refractive power at the center thereof and a negative refractive power at the peripheral thereof;

a second lens having a relatively large positive refractive power;

a third lens having a positive refractive power;

a fourth lens having a negative refractive power; and

a diffractive optical element formed on at least one surface of said lenses, wherein the fourth lens and the diffractive optical element have chromatic dispersion characteristics opposite to one another.

75. The projection lens system of claim 74, wherein the third lens forces the chromatic aberrations to decrease thus enhancing the chromatic aberration correction characteristic of the projection lens system.

76. The projection lens system of claim 74, wherein the diffractive optical element is formed on at least one surface of said lenses, and wherein the fourth lens enables a focal length of a blue light beam to be shorter than that of a red light beam and the diffractive optical element forces a focusing distance of the red light beam to be shorter than that of the blue light beam, thus correcting chromatic aberrations.

77. The projection lens system of claim 74, wherein the combination of the lenses correct chromatic aberrations and provide positive refractive power.

78. The projection lens system of claim 74, wherein the shape of the first lens and the shapes of the third and fourth lenses are defined by the following equation:

$$X(r) = (cr^2/(1+(1-(1+K)c^2 r^2))^{1/2}) + Ar^4 + Br^6 + Cr^8 + Dr^{10} + Er^{12},$$

wherein X(r) is a sag value with reference to an aspheric surface at a height r from an optical axis, c defines a curvature of a lens surface at the height r from an optical axis, K is a conic constant, and A to E define aspheric coefficients.

79. The projection lens system according to claim 74, wherein the combination of lenses in the projection lens system does not require additional lenses having a negative refractive power to enlarge the dispersion of a beam.

80. The projection lens system according to claim 74, wherein the second lens provides the majority of the positive refractive power and the diffractive optical element corrects aberrations caused by the second lens, thus allowing providing a thin projection system.

81. The projection lens system according to claim 74, wherein said first, third and fourth lenses are each designed to have an aspheric surface, wherein the shape of each of the first, third and fourth lenses is designed to work in conjunction with the others of the first, third and fourth lenses to correct aberrations.

82. The projection lens system of claim 19, wherein the combination of the lenses correct chromatic aberrations and provide positive refractive power.